# MOVEMENTS OF RAINBOW TROUT *(SALMO GAIRDNERI)* AND SPLAKE *(SALVELINUS FONTINALIS X S. NAMAYCUSH)* IN A SMALL ONTARIO LAKE AS REVEALED BY ULTRASONIC TELEMETRY

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## ABSTRACT

Betteridge, G. 1985. Movements of rainbow trout (*Salmo gairdneri*) and splake (*Salvelinus fontinalis* x *S. namaycush*) in a small Ontario lake as revealed by ultrasonic telemetry. Ont. Fish. Tech. Rep. Ser. No. 18: iii & 10p.

The movements of three rainbow trout and three splake, carrying surgically implanted ultrasonic transmitters, were monitored in a 93 hectare lake over a one month period. Tracking was continued for a further 51 days for one of the rainbow trout and 70 days for one large splake. Rainbow trout behaviour seemed to be influenced by food item availability, and splake movements by water temperature changes. Both species ranged widely throughout the lake, but only splake were regularly located within or near any of four man-made brush shelters. Splake became more sedentary as waters warmed, and one large fish "homed" to a cool water seepage area for three months. Rainbow trout were generally more active on a day-to-day basis than splake, and were often found in warm, nearshore waters. Two of the rainbow trout exhibited distinct daily movement patterns.

Surgical procedures proved successful, as three transmitters were recovered from angler-caught rainbow trout 62 to 385 days following implantation. Two units were surgically removed from trap netted splake which were subsequently released. One of these fish was caught by an angler 208 days later. All five of the fish were in good condition at time of recapture, and had increased in length while at large.

Keywords: ultrasonic, movements, splake, rainbow trout, temperature, feeding

# MOVEMENTS OF RAINBOW TROUT *(Salmo gairdneri)* AND SPLAKE *(Salvelinus fontinalis* x *S. namaycush)* IN A SMALL ONTARIO LAKE AS REVEALED BY ULTRASONIC TELEMETRY

## INTRODUCTION

The objectives of this study were: (1) to monitor, by means of surgically implanted ultrasonic transmitters, the daily movements and general behaviour of rainbow trout *(Salmo gairdneri)* and splake *(Salvelinus fontinalis* x *S. namaycush)* planted several years previously in a small Ontario lake, with particular reference to four man-made brush shelters provided therein; and (2) to assess the performance of six ultrasonic transmitters designed and built by personnel of the Wildlife Branch, Research Section, Ontario Ministry of Natural Resources.

Since the inception of underwater ultrasonic transmitters for monitoring movements of large migratory salmonids (Trefethen 1956; Johnson 1960), these and radio-tracking devices have been redesigned and modified (Henderson et al. 1966; Prince and Maughan 1978) to accommodate research into an increasingly varied range of fisheries investigations. Among these have been migration (Madison et al. 1972; Dodson et al. 1972), homing behaviour (McCleave and Horrall 1970), net avoidance (Parrish 1969), and the influences on fish movement of dock construction (Chamberlain 1979) and thermal plumes (Monan et al. 1975; Kelso 1976).

Studies of this sort have provided evidence on movement and behaviour patterns for at least 40 species of fishes (Stasko and Pincock 1977), but only minimal biotelemetric research has been done for rainbow trout in small lakes (Kazihara et al. 1969), and none for splake in any situation. The present study afforded an opportunity, therefore, to monitor the general activities of 3 rainbow trout and 3 splake during June, 1982 and to gauge the suitability of the tracking system for future use.

## STUDY AREA

This investigation was conducted in Billy Lake situated in the southeast sector of Algonquin Provincial Park at 45°38'N, 78°07'W (Fig. 1). It is a 93 hectare, shallow (mean depth = 4.6 m, maximum = 8.5 m) lake (Table 1) described previously by Fraser (1972).

Since 1962, this lake has received annual plantings of yearling and fall fingerling brook trout *(Salvelinus fontinalis)* splake and rainbow trout (J.M. Fraser, pers. comm.) During the winter of 1972, in order to provide cover and forage areas for newly stocked salmonids, 4 large (tops: 8-10 m, crowns: 6-8 m) hard maple *(Acer saccharum)* and yellow birch *(Betula allegheniensis)* "brush shelters" were installed in the lake (Fig. 1). These cuttings were tied together and arranged into 4 'X'-shaped piles on the ice surface, with arms extending 30 m or more, then the arrangements were anchored with cement blocks to sink them at ice out. Assessment of shelter use by lake fishes has been difficult and inconclusive to date, however, and it was hoped that a telemetry study might provide insight into this particular aspect of salmonid behaviour.

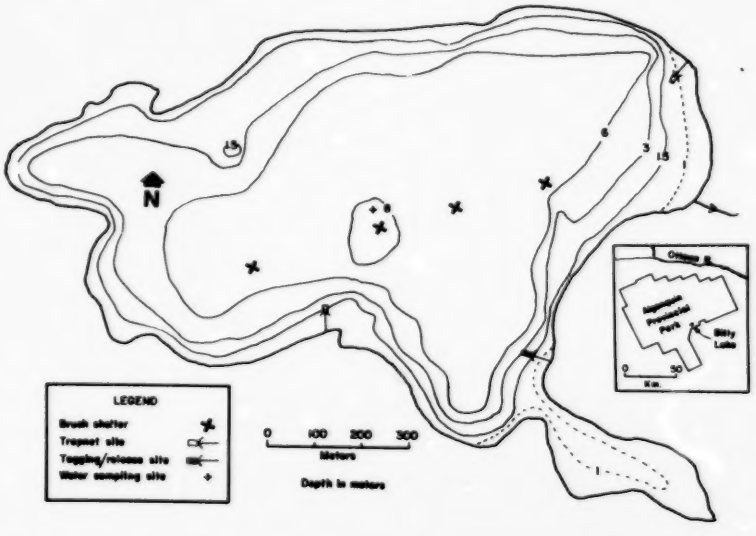


**Figure 1. Map showing the study area and location of Billy Lake (inset) in Algonquin Provincial Park.**

Table 1. Physical and chemical characteristics of Billy Lake, May 31 to June 28, 1982.

| Depth (m) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| May 31 | | | | | | | | | |
| Temperature (°C) | 20.5 | 18.7 | 17.0 | 15.2 | 12.8 | 9.0 | 7.4 | 6.7 | 6.4 |
| Dissolved oxygen (ppm) | 10 | - | 10 | - | 9 | - | 9 | 7 | 4 |
| pH | 6.3 | - | - | - | - | - | - | - | 6.1 |
| Secchi disk (m) | - | - | - | - | - | 5.7 | - | - | - |
| June 14 | | | | | | | | | |
| Temperature (°C) | 18.5 | 18.5 | 18.5 | 18.5 | 18.5 | 11.0 | 8.0 | 7.0 | 7.0 |
| Dissolved oxygen (ppm) | 12 | - | 10 | - | 8 | - | 8 | 5 | 5 |
| pH | 6.4 | - | - | - | - | - | - | - | 6.1 |
| Secchi disk (m) | - | - | - | 3.5 | - | - | - | - | - |
| June 28 | | | | | | | | | |
| Temperature (°C) | 20.1 | 19.9 | 19.5 | 17.8 | 17.2 | 14.0 | 9.0 | 7.6 | 7.2 |
| Dissolved oxygen (ppm) | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 6 | 4 |
| pH | 6.4 | - | - | - | - | - | - | - | 6.1 |
| Secchi disk (m) | - | - | - | - | 4.5 | - | - | - | - |

## MATERIALS AND METHODS

### ULTRASONIC TRACKING EQUIPMENT

The ultrasonic transmitters used (Table 2) were small (50-55 mm in length), cylindrical (8-11 mm in diameter) and lightweight (10.5-12.0 g in air). Transmitter assemblies were coupled with either 3.6 or 7.2 volt lithium thionyl chloride batteries (Battery Engineering, Hyde Park, Mass.), which proved a superior power source for the miniaturized circuitry (J. S. Lotimer, pers. comm.) The completed tag/battery packages, except for two connecting wires, were potted in molten Elvax 220 (DuPont reg. tm), a biologically compatible compound. Electronic performance and output was tested, with resulting specifications documented for subsequent field use. On May 27, 1982, 1.5 to 2 h prior to implantation, the two circuit closing wires were connected and soldered, frequencies and pulse rates checked using tracking gear, and the open ends of each transmitter coated in Elvax 220 to seal the assemblies. A Bayshore Systems receiver model FL24, Smith Root SR70 hydrophone, and Realistic monophonic headphone comprised the receiving system. This portable setup was installed on the boat prior to each tracking session, and could be readily operated by either one or two persons.

Table 2. Specifications of ultrasonic transmitters implanted in Billy Lake splake and rainbow trout on May 27, 1982.

| Transmitter | Weight in water (g) | Freq. (khz) | Pulse rate (bps) | Est. range (m) | Est. battery life (weeks) |
|---|---|---|---|---|---|
| P8105 | 6.3 | 96.5 | 116 | 350+ | 3 |
| P8106 | 6.4 | 77 | 46 | 250+ | 4 |
| P8113 | 5.6 | 54 | 106 | 100 | 12 |
| P8104 | 5.3 | 100 | 84 | 150-200 | 20 |
| P8112 | 6.2 | 54 | 80 | 400+ | 4 |
| P8114 | 5.6 | 63 | 102 | 500+ | 3.5 |

### FISH CAPTURE AND TRANSMITTER IMPLANTATION

On May 26, 1982, 3 rainbow trout and 3 splake were captured in 1.8 m trap nets set in Billy Lake, and were transferred to a holding net (Fig. 1). On the following day, these fish were individually removed from the trap net and anesthetized in an approximately 1:8000 solution of MS222 until opercular movement stopped (usually 1 to 1.5 min). The ventral surface of each fish was rinsed with distilled water and, commencing 6-7 cm anterior to the pelvic girdle origin, an incision 3 cm in length was made posteriorly, using a fine bladed, sterilized knife. Prior to being implanted, each transmitter was soaked in disinfectant (Dettol) and rinsed with distilled water. The transmitter was inserted by hand into the body cavity with utmost care to avoid damaging internal organs. Two sutures of black monofilament polyethylene were applied at 1 cm intervals, one from either end of the incision, secured tightly and trimmed closely.

Surgical procedures were similar to those detailed by Hart and Summerfelt (1975) for flathead catfish *(Pylodictis olivaris)* Implantation of body cavity transmitters has been used successfully for species ranging in size from muskellunge *(Esox masquinongy)* (Crossman 1977) to white bass *(Roccus chrysops)* (Henderson et al. 1966) and bluegill *(Lepomis macrochirus)* (Prince and Maughan 1978).

Species, fork length (to nearest mm), fin clip, transmitter code and tag number (if present) were recorded for each fish prior to release (Table 3). The fish was then placed in a pocket of water on top of the trap net to recuperate. Surgery and implantation required less than 3 min per fish. Additionally, 5-10 min in the lake proved sufficient for the fish to recover from anesthesia, re-orient itself and swim away. According to Zimmerman (1980), rainbow trout subjected to surgical procedures, without transmitter implantation, were not perturbed by the operation.

An initial check of transmitter frequencies and pulse rates indicated that all 6 fish were locally active within 100 m of the tagging site for up to one hour after release. On the day following tagging, 4 of the 6 fish located were at the far western end of the lake 1.0 to 1.2 km from the release site.

Table 3. Characteristics of fish tracked in Billy Lake, 1982.

| Transmitter number | Fish No. | Species | FL[a] (cm) | Fin clip | Disc No.[b] | Age (yr) |
|---|---|---|---|---|---|---|
| P8105 | 05 | rainbow | 39.0 | nil | none | 2+ |
| P8106 | 06 | rainbow | 38.6 | nil | 135672 | 2+ |
| P8113 | 13 | rainbow | 37.0 | nil | none | 2+ |
| P8104 | 04 | splake | 67.0 | r. pect. | 135598 | 9+ |
| P8112 | 12 | splake | 40.8 | l. pelv. | 135578 | 3+ |
| P8114 | 14 | splake | 41.8 | l. pelv. | 135574 | 3+ |

[a] Approximate weights of rainbow trout and Splake 12 and 14 were 500 g each. Splake 04 weighed about 3600 g.
[b] From previous trap netting and tagging.

FIELD PROCEDURES

The system used in this study allowed for ultrasonic tracking to be carried out by one or two persons in a 4.2 m aluminum boat powered by a 7.5 hp outboard motor. Numerous field studies have indicated that ultrasonically tagged fish exhibit little or no reaction to outboard noise (Warden and Lorio 1975; McCleave et al. 1977).

The fish locating procedure used was similar to the direction receiving system described by McCleave and Horrall (1970), whereby a weak and highly directional signal, indicative of a distant transmitter, was detected by the hydrophone/boat operator who would motor towards it. The boat was steered in the direction of the strongest incoming signal, positioned over the source (signal very strong and omnidirectional), and then driven beyond the transmission (signal became directional astern). Under ideal conditions (no wind, stationary transmitter, experienced tracker), Stasko and Pincock (1977) found that a transmitter suspended in 30 m of water could be located to within 10-15 m and, ideally, in shallower water, transmitter location could be determined to within a few meters. Since fish in Billy Lake could swim at depths ranging to a maximum of only 8.5 m, it was assumed that the directional system would provide highly accurate location fixes for individual fish.

On most tracking days, an attempt was made to obtain at least two position fixes for each fish, although this was not always possible because of undue signal attenuation, equipment failure or inclement weather. Commencing in the southeast corner of the lake, an initial check of all frequencies was made by lowering the hydrophone into 1 m of water beside the boat, rotating the receptor slowly through 360°, and listening for incoming signals on the headphones. The direction and strength of each signal was noted and traced, then the time and precise location (determined by shoreline landmarks) were plotted on individual 1:5500 lake map transparencies.

Generally, frequency checks were made at locations throughout the lake which afforded optimum lines of reception, such as bay mouths and prominent points. With practice, it was possible for operators to locate all six fish within 1.5 h. In 29 days of ultrasonic tracking, from May 28 to June 30, 1982, 277 position fixes were plotted for 3 rainbow trout and 3 splake in Billy Lake. Of these, 30% were obtained in the morning (08:30-11:59), 44% in the early afternoon (12:00-14:59), 18% in the

late afternoon (15:00-17:59), and 8% in the evening (18:00-21:00). Additionally, 20 and 46 fixes were made at irregular intervals for Rainbow 13 and Splake 04, until August 20 and September 8, respectively. One continuous nocturnal (20:00-24:00 h) track and one continuous morning (07:00-12:00 h) track was done for Splake 04 on August 4 and 5.

Measurements of dissolved oxygen, a water temperature profile, pH, and secchi visibility were obtained on a bi-weekly basis (Table 1) from a station located roughly at lake center. A further detailed investigation of water temperatures was conducted in a southwest bay on August 6. A notice posted at the primary public access point to Billy Lake informed anglers of the tracking study, and advised that a $10 reward would be offered for the return of any transmitters.

## RESULTS

### RAINBOW TROUT MOVEMENTS

Rainbow trout were seldom stationary, rarely spent extended periods of time in brush shelter areas, and swam at minimum calculated speeds averaging 12 cm $sec^{-1}$ or 0.3 body lengths (bl) $sec^{-1}$ (Table 4). Variations in weather conditions, including wind speed and direction, cloud cover, air temperature, and the onset of thunderstorms, or changes in water conditions seemed to have no measureable effects on fish behaviour.

A large emergence of *Ephemeroptera* sp. in the shallow northeast bay of Billy Lake, from May 30 to June 1 attracted all three rainbow trout to that area for the duration of the

Table 4. Calculated minimum swimming speeds (cm $sec^{-1}$) determined from selected time to position fixes for 3 rainbow trout in Billy Lake, May 28 to June 30, 1982.

| Date | Time interval min (sec) | Minimum distance travelled m(cm) | Minimum swimming speed ($cm\ sec^{-1}$) | No. of fixes | Mean minimum swimming speed ($cm\ sec^{-1}$) | Standard error |
|---|---|---|---|---|---|---|
| RAINBOW 05 (39.0 cm) | | | | 13 | 12.11 | 2.81 |
| May 29 | 155(9,300) | 1050(105,000) | 11.29 | | | |
| | 90(5,400) | 350(35,000) | 6.48 | | | |
| May 30 | 145(8,700) | 850(85,000) | 9.77 | | | |
| | 110(6,600) | 500(50,000) | 7.58 | | | |
| Jun 4 | 50(3,000) | 600(60,000) | 20.00 | | | |
| | 105(6,300) | 500(50,000) | 7.94 | | | |
| Jun 7 | 90(5,400) | 500(50,000) | 9.26 | | | |
| | 90(5,400) | 750(75,000) | 13.89 | | | |
| Jun 12 | 95(5,700) | 300(30,000) | 5.26 | | | |
| | 80(4,800) | 225(22,500) | 4.69 | | | |
| | 30(1,800) | 200(20,000) | 11.11 | | | |
| | 60(3,600) | 200(20,000) | 5.56 | | | |
| Jun 26 | 15(900) | 400(40,000) | 44.44 | | | |
| RAINBOW 06 (38.6 cm) | | | | 8 | 11.94 | 2.94 |
| May 28 | 175(10,500) | 550(55,000) | 5.24 | | | |
| Jun 4 | 35(2,100) | 400(40,000) | 19.05 | | | |
| | 135(8,100) | 650(65,000) | 8.02 | | | |
| Jun 12 | 90(5,400) | 325(32,500) | 6.02 | | | |
| | 100(6,000) | 425(42,500) | 7.08 | | | |
| | 80(4,800) | 400(40,000) | 8.33 | | | |
| Jun 28 | 125(7,500) | 800(80,000) | 10.67 | | | |
| Jun 30 | 40(2,400) | 750(75,000) | 31.25 | | | |
| RAINBOW 13 (37.0 cm) | | | | 3 | 9.60 | 0.60 |
| Jun 3 | 100(6,000) | 550(55,000) | 9.17 | | | |
| Jun 4 | 140(8,400) | 650(65,000) | 7.74 | | | |
| Jun 6 | 35(2,100) | 250(25,000) | 11.90 | | | |

observed hatch. One general behaviour pattern noted for Rainbows 05 and 06 may have been associated with feeding. The two fish spent most of their daylight hours in the eastern half of the lake, returned to overnight in the western end, then moved eastward on the following morning. Both fish were later caught by anglers during low light hours from the same west end location, where it is reported by creel survey crews that rainbow trout angling is best during the early morning and late evening. Seven lake traverses were noted for these two fish and of these, five (Fig. 2) were used in determining minimum swimming speeds.

The majority of location fixes for rainbow trout were in nearshore areas and in the eastern half of the lake (Fig. 3), where the sport fishing effort is most concentrated. From June 1 to 15, the catch-per-unit-effort (CUE), or number of rainbow trout taken per angler-hour, was a seasonal high 0.18. Observed changes in trout movements during the latter half of the month were reflected in a decreased CUE of 0.05 for the June 16 to 30 period. Over that period, two of the fish were located in rarely angled nearshore and west end areas, and the third rainbow trout ranged within the central part of the lake. The last transmitter signals from Rainbows 05, 06, and 13 were received, respectively, on June 28, June 30, and August 20, 1982. All three fish were taken by angling and two transmitters (P8106, P8113) were recovered intact, in reusable condition.

## SPLAKE MOVEMENTS

All three splake ranged widely throughout the lake, particularly during the May 28 to June 9 period. Splake 12 and 14 tended towards deeper waters and Splake 04 was most often located in the littoral zone within 200 m of shore (Fig. 4). Calculated minimum swimming speeds averaged 7.5 cm $sec^{-1}$ (Table 5) or 0.2 bl $sec^{-1}$ for the two smaller fish, while the large splake averaged 25.8 cm $sec^{-1}$ (0.4 bl $sec^{-1}$), and on one occasion it traversed Billy Lake at the rate of 1.0 bl $sec^{-1}$ (Fig. 5).

Neither weather changes nor variations in water condition, such as wave height or turbidity, seemed to have any discernible effect on the movements of splake, although increasing water temperature appeared to influence their behaviour after June 10. From that day until June 28, the three fish were more sedentary than they had been earlier in the month. Splake 04 settled into one bay from June 11 onward, and neither of the other two splake were located in water <3 m deep after June 14, when the water temperature at 4 m was 18.5°C. June 6 was the last date on which either Splake 12 or 14 was found within the defined 'home' territory of Splake 04. None of the splake were attracted to the area of the large May 30 to June 1 mayfly hatch.

The relative immobility of Splake 04 from mid-June to early August prompted an investigation of water temperatures in the southwest

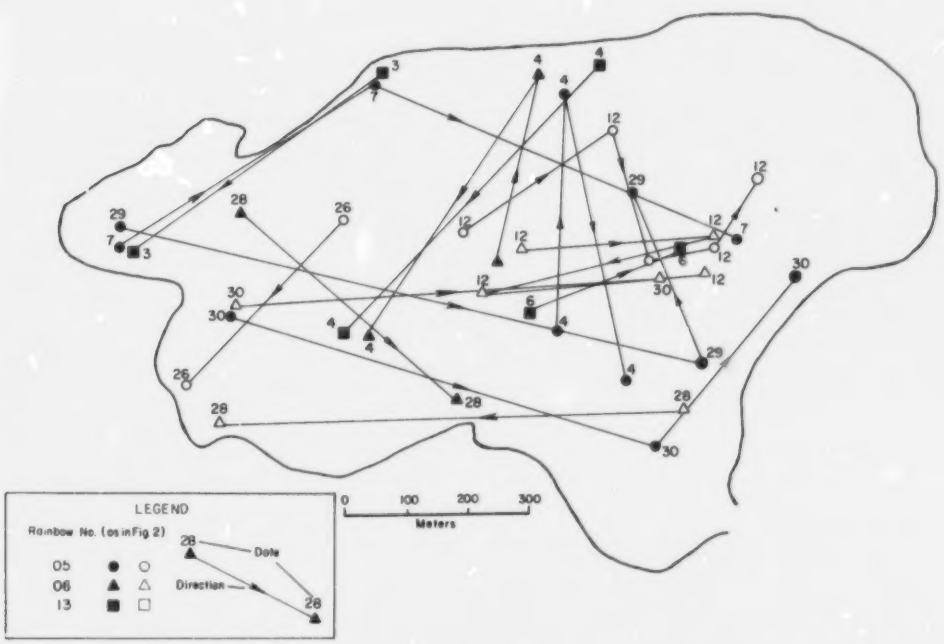


Figure 2. Movements of 3 rainbow trout tracked ultrasonically in Billy Lake, 1982, from which time/distance calculations were made (Table 4).

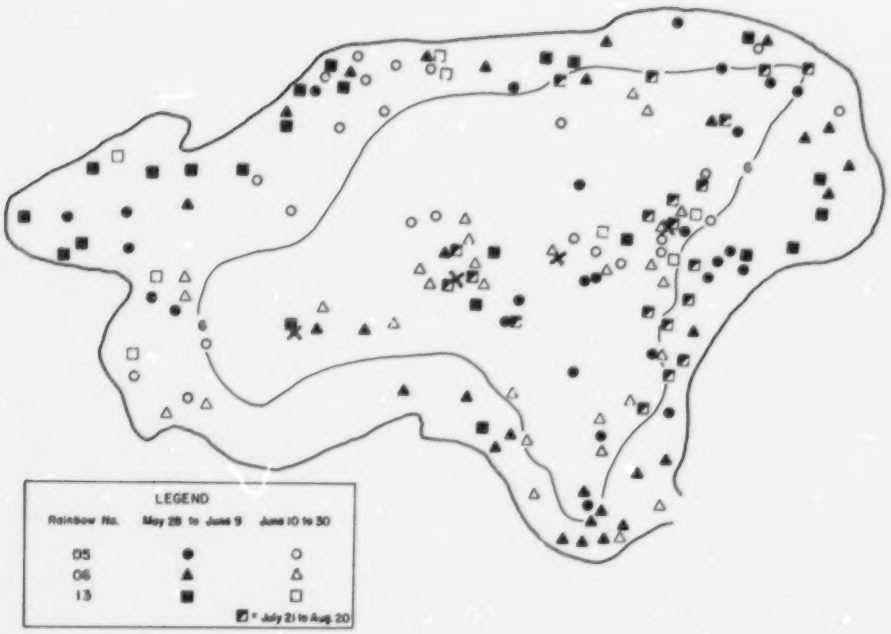


Figure 3. Composite of all location fixes for 3 rainbow trout tracked ultrasonically in Billy Lake from May 28 to June 30 (Rainbows 05 and 06) and from May 28 to August 20, 1982 (Rainbow 13).

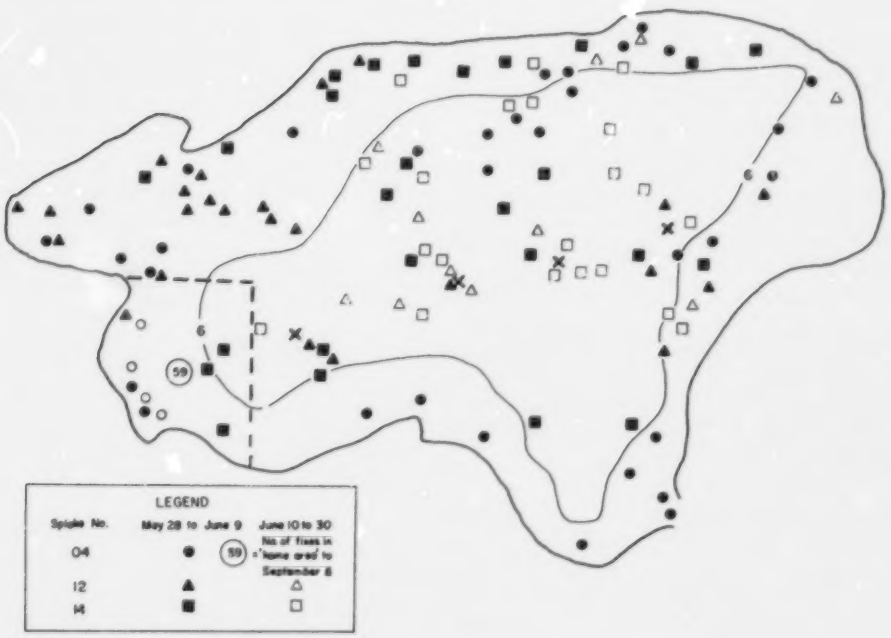


Figure 4. Composite of all location fixes for 3 splake tracked ultrasonically in Billy Lake from May 28 to June 30, 1982

Table 5. Calculated minimum swimming speeds (cm $sec^{-1}$) determined from selected time to position fixes for 3 splake in Billy Lake, May 28 to June 18, 1982.

| Date | Time interval min (sec) | Minimum distance travelled m(cm) | Minimum swimming speed (cm $sec^{-1}$) | No. of fixes | Mean minimum swimming speed (cm $sec^{-1}$) | Standard error |
|---|---|---|---|---|---|---|
| SPLAKE 04 (67.0 cm) | | | | 4 | 25.79 | 11.82 |
| May 29 | 35(2,100) | 250(25,000) | 11.90 | | | |
| May 30 | 70(4,200) | 450(45,000) | 10.71 | | | |
| Jun 7 | 90(5,400) | 750(75,000) | 13.89 | | | |
| Jun 8 | 25(1,500) | 1000(100,000) | 66.67 | | | |
| SPLAKE 12 (40.8 cm) | | | | 3 | 7.09 | 0.43 |
| Jun 7 | 205(12,300) | 900(90,000) | 7.32 | | | |
| Jun 9 | 220(13,200) | 800(80,000) | 6.06 | | | |
| Jun 12 | 95(5,700) | 450(45,000) | 7.90 | | | |
| SPLAKE 14 (41.8 cm) | | | | 5 | 7.74 | 1.00 |
| May 29 | 50(3,000) | 200(20,000) | 6.67 | | | |
| Jun 4 | 65(3,900) | 350(35,000) | 8.97 | | | |
| | 80(4,800) | 550(55,000) | 11.46 | | | |
| Jun 12 | 80(4,800) | 300(30,000) | 6.25 | | | |
| Jun 18 | 125(7,500) | 400(40,000) | 5.33 | | | |

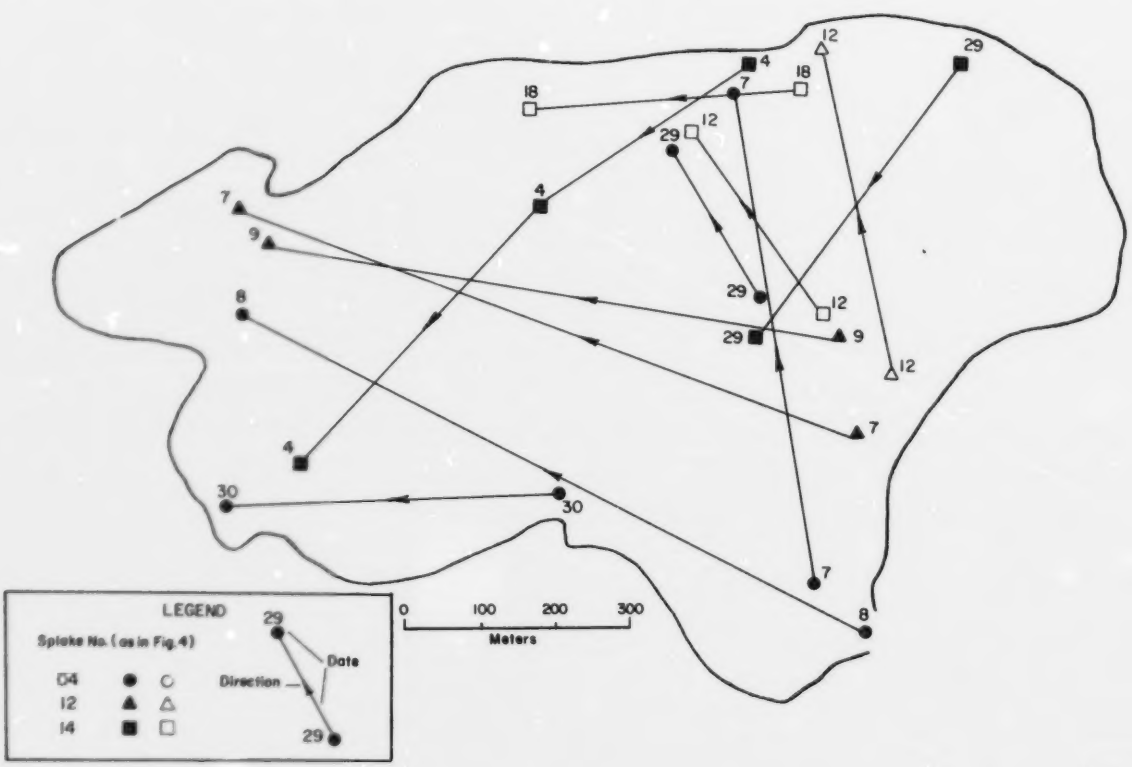


Figure 5. Movements of 3 splake tracked ultrasonically in Billy Lake, 1982, for which time/distance calculations were made (Table 5).

quarter of Billy Lake. An August 6 survey of the southwest bay area of Billy Lake indicated a heretofore unknown seepage or bottom upwelling. Eighty thermistor readings, taken at depths of 1.5 to 3 m, revealed temperatures of 1 to 8°C less than the ambient 21°C for the same depths in the rest of the lake (Fig. 6).

It was subsequently found that, within the seepage area, this large fish preferred waters in the 13 to 16°C range (Fig. 6). An August 4 to 5 nighttime track revealed a marked increase in the activity level of Splake 04 after sunset, with a decrease in movement after 08:00. This splake was last located on September 8, still moving within its 'home' zone. Final transmission signals were received for Splake 12 and 14 on June 28, 1982. Both fish were subsequently recaptured in an October trapnet set (Table 6), and the intact transmitters were surgically removed and the splake returned to the lake in apparent good health. Splake 12 was taken by an angler on May 7, 1983.

## TRANSMITTER PERFORMANCE

During the May 28 to June 9 period, transmitter signals ranged from very strong (up to twice the predicted range) to weak and intermittent, but were usually near predicted values (Table 2). Reception was very poor whenever tracked fish were in the vicinity of, or in line with, any of the four brush piles in Billy Lake. This, in part, may have accounted for the fewer position fixes obtained during the June 10 to 30 period. Signal strength seemed also to be diminished variously by the presence of high plankton densities, moisture in the receiving unit, and a flat calm lake surface. Frequency and pulse rate fluctuations were minimal, and in all cases battery life either met or exceeded expectations.

Figure 6. Monthly position fixes for Splake 04 within 'home territory' of Billy Lake for: June □, July ◣, August ●, and September ○, 1982

Table 6. Post-tracking history of 3 rainbow trout and 2 splake in Billy Lake to June 13, 1983.

| Fish number | Fork length[a] May 27/82 | Recapture date k=killed r=released | Fork length (Δ FL) | Recapture date | Fork length (Δ FL) |
|---|---|---|---|---|---|
| Rainbow 05 | 39.0 | Aug 8/82-k | 40.9 (+1.9) | | |
| Rainbow 06 | 38.6 | Jul 28/82-k | 42.9 (+4.3) | | |
| Rainbow 13 | 37.0 | Jun 13/83-k | 40.7 (+3.7) | | |
| Splake 12 | 40.8 | Oct 9/82-r | 44.8 (+4.0) | May 7/83-k | 48.7 (+3.9) |
| Splake 14 | 41.8 | Oct 11/82-r | 44.6 (+2.8) | | |

[a] All fork lengths are in cm.

## DISCUSSION

The results of this investigation indicate certain behavioural differences between rainbow trout and splake in a small, mesotrophic lake. Rainbow trout occasionally passed through the brush shelter zones, but no continuous position fixes were made on them within any of those four areas. Conversely, splake were often located moving locally within or near the brush piles. Splake 12 and 14 were found exclusively in the deeper central portion of the lake after June 14 and they were the only two fish to remain deep. Rainbow trout, when sedentary at all, were in nearshore waters <4 m deep.

Although water temperature preferenda could not be firmly ascertained, Splake 04 'homed' to a zone tempered by cool seepage water (13 to 16°C), and the other two splake were located primarily in waters ranging from 8 to 14°C after mid-June. Berst and McCombie (1975) suggested that splake preferred water temperatures of 12°C, and it appeared that Billy Lake splake sought waters near this preferendum. Rainbow trout movements were seemingly unrestricted by temperature changes and the fish were regularly found in waters as warm as 20°C.

Forays by rainbow trout into select areas for several days in succession were most probably associated with the seasonal availability of various food items. An observed mayfly hatch coincided with the presence of all three fish in one bay for up to three days. All 22 rainbow trout stomachs examined from May 25 to June 15 angler catches contained *Chironomidae* sp. larvae and/or pupae. Only 31 of the 62 stomachs checked after that date contained chironomids. Of those 62, 60% contained zooplankton, an item which had not been in any of the 35 total rainbow trout stomachs analysed from May and June catches (unpubl. data, 1982).

It seemed that splake may have been less opportunistic feeders, since none of the tracked fish foraged on the readily available emerging mayflies in late May. Seasonal stomach content analyses of 44 angler-caught splake indicated a preference for yellow perch (*Perca flavescens*) and zooplankton, which comprised 46 and 40%, respectively, frequency of occurrence (unpubl. data, 1982).

Rainbow trout were usually more active on a day-to-day basis than splake, but both species ranged widely throughout the lake. The mean estimated minimum swimming speed of 0.3 bl $sec^{-1}$ for rainbow trout matched precisely the actual average swimming speed determined by Kazihara et al. (1969) for radio-tracked rainbow trout and for ultrasonically tracked brown trout (*Salmo trutta*) in a Scottish loch (Tytler et al. 1978). Although Tytler et al. (1978) indicated a maximum swimming speed of 2.0 bl $sec^{-1}$ for brown trout, the fastest swimming speeds recorded for rainbow trout and splake in Billy Lake were 1.1 and 1.0 bl $sec^{-1}$, respectively. A peak swimming speed of 1.0 bl $sec^{-1}$ was also noted for sunapee trout (*Salvelinus alpinus*) tracked ultrasonically in a Maine lake (McCleave et al. 1977).

The daily movement patterns of Rainbows 05 and 06, i.e. west (night) to east (day) to west (night), were notably similar to the homing tendencies described by Shepherd (1973) for cutthroat trout (*Salmo clarki*) in a small bog lake. The same author observed that 'home sectors' were rarely defended, but it seems that Splake 04 may have prevented Splake 12 and Splake 14 from entering its 'home' area after June 11.

Outboard motor noise did not appear to influence the movements of rainbow trout and splake, but the effects of changing water and weather conditions on fish behaviour could not be positively determined. Ultrasonic transmitters worked well and, as Mitson (1978) suggests, they offer superior locating accuracy over radio tags. Signals were not attenuated by fish flesh and reception was acceptable under most circumstances.

Neither the presence of the transmitters nor the surgical implantation procedures seemed to have any deleterious long-term effects on the fish. Post-operative examination of 3 rainbow trout and 2 splake showed that incisions had healed completely and that all of the fish were in fine condition. Five of the six fish in the Billy Lake investigation were recaptured, all had grown during their several months at large, and at least one splake survived both transmitter implantation and removal operations.

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